PHYTOTOXICOLOGY SURVEYS IN THE VICINITY OF CAMCO, HAMILTON 1986 and 1987

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Introduction

In the late summer of each year since 1983, surveys were conducted in the vicinity of CAMCO, Hamilton to determine whether airborne emissions from this enamelling operation were having an effect on vegetation and soil in the area. The results of these Phytotoxicology investigations in the vicinity of CAMCO, Hamilton showed that although there was little or no injury to vegetation which could be directly attributed to airborne emissions from the operation, boron concentrations in the soil were greater than normal background at many locations. This report provides the results for the surveillance program which was continued in 1986 and 1987.

Methods

In 1983, eight monitoring stations were selected for observation and for the collection of tree foliage and soil samples (0-5 cm) for chemical analysis. This was expanded to ten sites in 1985. In 1986, two sites (Sites 2 and 8) were deleted but three new sites were added in an attempt to improve the area covered by the survey. Sampling of soil and foliage was carried out at these same sites in 1987. Sampling stations are shown in the attached map.

The availability of tree species at the monitoring stations dictated some modifications to the sampling of vegetation in 1985. In 1986, another modification was made to carry out sampling using Manitoba maple as the common denominator species for all stations except Station 3 where only honey locust was available. Individual samples composed of foliage from several branches were taken from sampled trees. Soil samples consisted of a minimum of 15 cores distributed uniformly over the sample area.

The vegetation at each site was evaluated for injury and symptoms were noted. The samples were brought to the Phytotoxicology Laboratory for processing. The vegetation samples were divided into two portions and one of these portions was washed using a standardized procedure involving the use of in Alconox - Na EDTA solution. The washing procedure was not used in 1987. The samples were then oven-dried, ground in a Wiley Mill and stored in glass bottles. The soil samples were air-dried, crushed to pass through a 45 mesh sieve and stored in glass bottles. All samples were analyzed for boron and fluoride (vegetation only) by the Inorganic Trace Contaminants Section of the Ministry of the Environment laboratory at Resources Road.

In 1987, the soil samples were also prepared to determine the amount of boron available to plant roots. This technique involves extraction of a known weight of soil with boiling water followed by analysis of the water for boron. This procedure has been found to provide a good estimate of the amount of boron in the soil that can be taken up by plant roots.

Visual Assessment

The observed conditions of the foliage of vegetation growing in the vicinity of CAMCO, Hamilton in 1986 and 1987 are summarized in Tables 1 and 2 respectively. In addition to normal insect injury and disease, trace amounts of injury to foliage were noted throughout the area; however, the most severely injured trees were located at Station 9 (300 m NE) and to a lesser extent in 1986 at Station 11 (650 m) of the CAMCO operation. The honey locust trees at Station 3 showed symptoms similar to those caused by drought; however, the exact cause of this condition was not apparent.

Chemical Analysis

The results of the analysis of samples of soil and foliage are presented in Tables 3 to 5. Data for years 1983 to 1985 have been

included for comparison purposes. Since earlier reports have discussed data to 1985, the content of the present report will be mainly restricted to 1986 and 1987 data.

Fluoride analytical results are shown in Table 3. Only samples of honey locust at Station 3 contained fluoride in excess of that considered to be background by the Phytotoxicology Section. Since more than half of this fluoride was removed by washing, it is considered to be associated with surface deposits. At Station 9, which is located close to CAMCO, the samples of Manitoba maple foliage contained fluoride in greater concentrations than at other maple sites; however, this was still within the normal range (<35 ug/g) for fluoride in vegetation. The maximum fluoride value was 38 ug/g in 1986 and 41 ug/g in 1987. Comparison of 1986 data with earlier years indicates a slight decline in fluoride content, notably at Stations 1 and 10. Values increased slightly from 1986 to 1987 at all stations. A portion of this increase could possibly be due to the later date of sampling in 1987 (3 weeks later) with a longer period over which fluoride accumulation could occur. In every case, washed samples contained lower amounts of fluoride than did the unwashed samples. This indicates that a substantial portion of the fluoride was present on the surface of the foliage and was removed during washing. None of the fluoride results were high enough to be associated with the foliar injury symptoms observed in either 1986 or 1987.

Boron concentrations in vegetation samples are summarized in Table 4. The upper limit of normal concentration of boron in vegetation (175 ug/g) was exceeded at three stations in 1986. This included Stations 3, 9 and 12 with a maximum of 590 ug/g in the sample collected at Station 9. In addition, samples collected at Stations 1, 4, 10 and 11 were also elevated, but were still at or within the normal range for boron in vegetation. In 1987, the boron concentration exceeded the upper limit of normal at eight stations including all seven sites where concentrations were elevated in 1986. In fact, only two sites (Stations 12 and 13) were within the normal boron concentration range for urban foliage.

Boron values appeared to increase in 1986 by comparison with earlier years at Stations 1 and 3. Boron concentration increased at all stations from 1986 to 1987 except at Stations 12 and 13. The concentration of boron decreased by over 80% at Station 12 although no explanation is readily apparent. Similar injury severity ratings to Manitoba maple at this site were recorded in both 1986 and 1987.

At Station 4 in 1986, the boron value decreased in the unwashed sample but increased in the washed sample compared to corresponding results from 1985. The procedure of washing samples had no consistent effect on the measured concentration of boron, suggesting that the boron was mainly internal but was variable from sample to sample.

For samples collected in 1986, the highest concentrations of boron were consistent with the greatest amount of injury to Manitoba maple foliage (moderate, marginal and terminal necrosis at Station 9). Light injury observed at Station 12 was apparently related to the second highest boron level measured (269 ug/g); however, similar amounts injury recorded at Station 13 were associated with the lowest boron content in Manitoba maple foliage. Trace amounts of injury at Stations 1 and 4 (and possibly 5) were probably due to the intermediate concentrations of boron. Despite the increase in boron concentration at most stations from 1986 to 1987, the degree of injury remained very similar in both years.

Boron concentrations in soil (Table 5) were in excess of the Upper Limit of Normal for urban soil (<15 ug/g) at all locations except Stations 1 and 6 in 1986. Although there were slight decreases (compared to 1985) in concentration at Stations 1, 9 and 10, there also were slight increases in boron levels at Stations 3 and 7. Clearly, these changes appear to fall within the variability of the data. The highest values were observed at Stations 3 and 9 which are the locations where foliar injury and high foliar concentrations of boron were recorded.

Except at Station 1, 1987 soil boron values decreased slightly at all stations. At four stations (Stations 5, 10, 11 and 13), the more recent (1987) concentrations were within the normal range for soil boron. As in 1986 and previous years the highest concentrations of 58 and 50 ug/g boron in 1987 were found at Stations 3 and 9, respectively.

The boron extraction procedure using hot water indicated that 5 samples had available boron in excess of 1 ug/g a level which has been associated with boron toxicity to sensitive plants. Generally, the higher total boron concentrations were associated with the higher available boron concentrations. The only exception to this trend was at Station 5 which had a higher than expected plant available boron concentration (1.2 µg/g). This result was however in line with total boron concentrations in soil from this site during earlier years (1983 and 1984).

Discussion

The elevated boron in the foliage is considered to have resulted from a combination of air and soil-borne boron. Since in some cases washing removed a portion of the boron from the foliage, then at least a small portion of the boron must be considered to be due to airborne deposition at these locations. The amount of soil boron which is available to the vegetation is dependent on several factors including soil texture and pH. Assessment of this route of boron uptake using the hot water extraction technique suggests that a significant portion of the boron content of the vegetation occurs through root uptake from accumulated boron in the soil.

In view of the fact that boron is no longer a major component in the production process, the majority of the boron present in the vegetation must, therefore, represent soil uptake of this element. It is expected that elevated boron in vegetation in this area will continue for several years as a result of annual biological cycling processes (i.e. leaf and twig fall) as well as the physical and chemical processes which govern residence time in the soil.

Realignment of the survey in 1986 by adding several stations and limiting the number of vegetation species failed to fully delimit the zone of influence of boron emissions from CAMCO. The data obtained do, however, suggest that the main effect is in the northeasterly direction. The situation found in 1986 was more or less confirmed by the survey carried out in 1987.

Summary

A surveillance program to monitor the effects of emissions on vegetation and soil in the vicinity of CAMCO, Hamilton was continued in 1986 and 1987. Injury to vegetation was noted mainly to the northeast of CAMCO and in most cases, was associated with elevated concentrations of boron in the foliage. An examination of the findings revealed that the major portion of the foliar boron has resulted from root uptake of plant available boron in the soil. As a result, foliar contamination and associated boron injury is expected to continue for several years.

The concentrations of boron in foliage were slightly higher in 1986 than in earlier years at several stations. Further increases were measured in 1987; however, this may in part be attributed to the later sample collection date. Fluoride values in sampled vegetation were normal except at one station (Station 3) which is located near the centre of the CAMCO complex. None of the foliar injury was attributed to fluoride contamination.

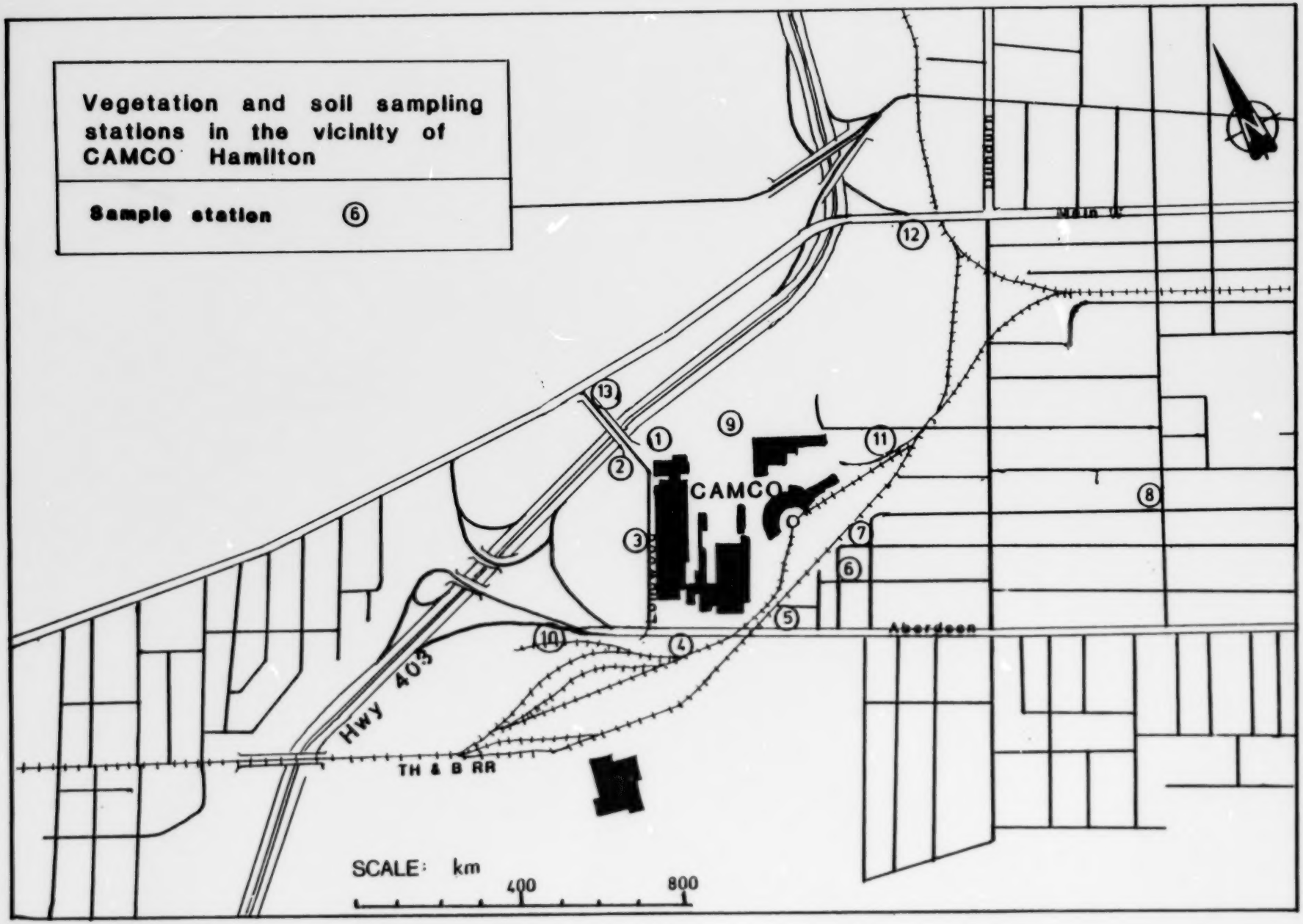
Vegetation and soil sampling stations in the vicinity of CAMCO Hamilton
Sample station ⑥
CAMCO
Main St
Aberdeen
Hwy 403
TH & B RR
SCALE: km
400
800

TABLE 1

Condition of vegetation foliage observed in the vicinity of CAMCO, Hamilton, August 18, 1986

Station	Species	Remarks
1	Manitoba maple	trace terminal and marginal necrosis on older leaves
	White ash	wind abrasion, anthracnose disease
	Hawthorn	rust disease
3	Honey locust	foliage golden brown, leaflets falling easily
4	Manitoba maple	trace terminal necrosis, moderate marginal and terminal chlorosis
5	Manitoba maple	trace terminal necrosis
	Walnut	light bacterial leaf spot
6	Manitoba maple	generally healthy, a few leaves with brown stipple
	White pine	old foliage only with light terminal necrosis
7	Manitoba maple	healthy
9	Manitoba maple	moderate marginal and terminal necrosis
	Wild grape	several marginal necrosis
	Choke cherry	several marginal bleaching
	White ash	intercoastal chlorotic blotches
	Sumac	moderate marginal necrotic stipple and trace necrosis
	Serviceberry	moderate intercoastal chlorosis, light marginal necrosis
10	Manitoba maple	healthy
11	Manitoba maple	moderate marginal chlorosis
12	Manitoba maple	light marginal and terminal necrosis and chlorosis
13	Manitoba maple	light terminal necrosis
	Sugar maple	trace to light terminal necrosis

TABLE 2

Condition of vegetation foliage observed in the vicinity of CAMCO, Hamilton, September 9, 1987

Station	Species	Remarks
1	Manitoba maple	light marginal necrotic spots
	Wild Grape	light insect
	Pear	blister mite
	White ash	heavy seed crop, light foliage
	Virginia Creeper	mildew
3	Honey locust	light terminal necrosis of leaflets dried with slight overall chlorosis
4	Manitoba maple	healthy
5	Manitoba maple	healthy
6	Manitoba maple	trace terminal and marginal necrosis
7	Manitoba maple	trace terminal and marginal necrosis
9	Manitoba maple	severe marginal necrosis
	Wild grape	severe chlorosis and moderate marginal necrosis
	Choke cherry	severe chlorosis and moderate marginal necrosis
	White ash	moderate - severe marginal spotting
	Sumac	severe marginal spotting
	Serviceberry	moderate marginal necrosis
	Honeysuckle	moderate marginal necrotic spotting
	Goldenrod	moderate marginal necrosis
	Coreopsis	moderate marginal necrosis
10	Manitoba maple	healthy
11	Manitoba maple	trace terminal necrosis and chlorosis
12	Manitoba maple	light marginal and terminal necrosis
13	Manitoba maple	healthy

TABLE 3

Fluoride Concentration (ug/g dry weight) in not washed and washed tree foliage collected in the vicinity of CAMCO, Hamilton 1983 to 1987

			Not Washed					Washed			
Stn.	Sample	Location	1983	1984	1985	1986	1987	1983	1984	1985	1986
1	Manitoba Maple	200 m N	18	7	-	6	16	7	6	-	5
	White Ash		-	-	8	-	-	-	-	4	-
3	Honey Locust	100 m WNW	-	-	33	38	41	-	-	18	12
4	Elm	250 m SSW	48	14	-	-	-	22	11	-	-
	Manitoba Maple		-	-	12	7	18	-	-	6	3
5	Silver Maple	300 m SSE	18	4	11	-	-	10	12	8	-
	Manitoba Maple		-	-	-	7	17	-	-	-	4
6	Norway Maple	400 m SE	17	9	-	-	-	5	6	-	-
	Sugar Maple		-	-	9	-	-	-	-	5	-
	Manitoba Maple		-	-	-	13	14	-	-	-	8
7	Norway Maple	450 m ESE	10	9	-	-	-	4	7	-	-
	Manitoba Maple		-	-	9	9	15	-	-	6	7
8	Norway Maple	1100 m ESE	9	7	-	-	-	4	6	-	-
	Manitoba Maple		-	-	11	-	-	-	-	7	-
9	Apple	300 m NE	-	-	29	-	-	-	-	19	-
	Manitoba Maple		-	-	-	21	26	-	-	-	17
10	Manitoba Maple	300 m WSW	-	-	33	5	9	-	-	18	3
11	Manitoba Maple	650 m E	-	-	-	7	13	-	-	-	4
12	Manitoba Maple	1000 m ENE	-	-	-	8	20	-	-	-	5
13	Manitoba Maple	400 m N	-	-	-	5	11	-	-	-	3

Underlined values exceed the Upper Limit of Normal guideline for fluoride concentration in foliage in an urban setting (35 µg/g).

TABLE 4

Boron Concentration (ug/g dry weight) in not washed and washed tree foliage collected in the vicinity of CAMCO, Hamilton 1983 to 1987

			Not Washed					Washed			
Stn.	Sample	Location	1983	1984	1985	1986	1987	1983	1984	1985	1986
1	Manitoba Maple	200 m N	109	100	-	175	219	93	110	-	197
	White Ash		-	-	31	-	-	-	-	36	-
3	Honey Locust	100 m WNW	-	-	94	196	307	-	-	110	162
4	Elm	250 m SSW	92	160	-	-	-	77	160	-	-
	Manitoba Maple		-	-	200	173	281	-	-	50	121
5	Silver Maple	300 m SSE	88	100	73	-	-	93	92	77	-
	Manitoba Maple		-	-	-	101	214	-	-	-	127
6	Norway Maple	400 m SE	104	100	-	-	-	89	96	-	-
	Sugar Maple		-	-	77	-	-	-	-	88	-
	Manitoba Maple		-	-	-	103	134	-	-	-	103
7	Norway Maple	450 m ESE	89	110	-	-	-	87	110	-	-
	Manitoba Maple		-	-	180	113	188	-	-	160	87
8	Norway Maple	1100 m ESE	63	86	-	-	-	65	92	-	-
	Manitoba Maple		-	-	70	-	-	-	-	85	-
9	Apple	300 m NE	-	-	52	-	-	-	-	48	-
	Manitoba Maple		-	-	-	590	639	-	-	-	610
10	Manitoba Maple	300 m WSW	-	-	170	166	259	-	-	190	167
11	Manitoba Maple	650 m E	-	-	-	163	251	-	-	-	141
12	Manitoba Maple	1000 m ENE	-	-	-	269	51	-	-	-	272
13	Manitoba Maple	400 m N	-	-	-	99	62	-	-	-	66

Underlined values exceed the Upper Limit of Normal guideline for boron in foliage in an urban setting (175 µg/g).

TABLE 5

Boron Concentration (ug/g dry weight) in soil (0-5 cm) collected in the vicinity of CAMCO, Hamilton 1983 to 1987

Station	Location	Total Soil Boron 1983	1984	1985	1986	1987	Extractable* Boron 1987
1	200 m N	17	21	20	15	22	1.4
2	200 m NNW	15	13	14	-	-	-
3	100 m WNW	54	260	53	70	58	2.6
4	250 m SSW	29	34	18	20	18	1.2
5	300 m SSE	21	45	17	16	4	1.2
6	400 m SE	20	57	14	15	11	1.0
7	450 m ESE	21	17	19	24	18	1.6
8	1100 m ESE	13	20	14	-	-	-
9	300 m NE	-	-	150	61	50	1.0
10	300 m WSW	-	-	34	21	15	0.6
11	650 m E	-	-	-	17	10	0.8
12	1000 m ENE	-	-	-	28	24	2.0
13	400 m N	-	-	-	21	9	0.4

Underlined values exceed the Upper Limit of Normal guideline for boron concentration in soil in an urban setting (15 µg/g).

*concentrations of plant available boron (µg/g) extractable by hot water. (see text).

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